AD-A102 909 NAVAL UNDERWATER SYSTEMS CENTER NEW LONDON CT NEW LO--ETC F/G 20/1
LONG-RANGE SOUND PROPAGATION ACROSS ATLANTIC OCEAN SEAMOUNTS: I--ETC(U)
AUG 81 P D KOENIGS, D G BROWNING
UNCLASSIFIED NUSC-TD-6523 NL

NUSC Technical Document 6523
12 August 1981

LEVEL II

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Long-Range Sound Propagation Across Atlantic Ocean Seamounts: Implications for Ambient Noise

A Paper Presented at the 101st Meeting of the Acoustical Society of America, 20 May 1981, Ottawa, Canada

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Preface

This document was prepared under the sponsorship of the Undersea Warfare Technology Office, Naval Sea Systems Command under NUSC Project No. A65005, *Ambient Noise Characteristics*; NAVSEA Program Manager, F. J. Romano, and NUSC Principal Investigator, D. G. Browning.

Reviewed and Approved: 12 August 1981

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(14) Technical document

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1. REPORT NUMBER TD-6523	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) LONG-RANGE SOUND PROPAGATION ACROSS ATLANTIC OCEAN SEAMOUNTS: IMPLICATIONS FOR AMBIENT NOISE. A Paper Presented at the 101st Meeting of the ASA, 20 May 1981, Ottawa, Canada		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) P. D. Koenigs, D. G. Browning, ~~and~~ R. F. LaPlante [redacted] R. L. Martin (Naval Ocean Research and Development Activity)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Underwater Systems Center New London Laboratory New London, CT 06320		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS A65005
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Sea Systems Command Washington, DC 20362	(11)	12. REPORT DATE 12 Aug[redacted]981 13. NUMBER OF PAGES 12
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (12) 16		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION / DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Ambient Noise
Low Frequency Propagation Loss
Slope Enhancement
Sound Channel Propagation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document contains the oral and visual presentation given at the 101st Meeting of the Acoustical Society of America, 20 May 1981, Ottawa, Canada.

A low frequency (50-800 Hz) sound-propagation experiment was conducted along a 1400-km path running eastward from Bermuda toward the Mid-Atlantic Ridge. SUS charges were detonated at depths of 18, 154, 615, and 1230 m. The receiver was located at the axis of the deep sound channel (1250 m) at a

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maximum range of 1300 km. The acoustic path crossed several seamounts of the Corner Seamount Group. The highest of these peaks rose to the sound axis. This paper presents the relative enhancement of signal level for SOFAR propagation due to these seamounts as a function of source depth and frequency. The enhancement was minimal for the 1230-m shots, while the greatest enhancement occurred for the 18-m shots at the 50-Hz filter band. This implies these seamounts and other topographic features such as the mid-Atlantic Ridge can significantly increase the coupling of low-frequency ship-generated noise into the deep sound channel.

Long-Range Sound Propagation Across Atlantic Ocean Seamounts: Implications for Ambient Noise

Introduction

Of the possible effects that seamounts can have on sound propagation, perhaps the most important is the scattering of ship generated low frequency noise in or out of the deep sound channel. As addressed by Wagstaff in last month's JASA, the slope conversion phenomenon is a major contributing mechanism in the generation of SOFAR channel noise.

Unlike controlled experiments where the peak of a single seamount is precisely crossed, a transiting ship crosses seamounts randomly and typically encounters groups of seamounts that have various slopes and heights. It is hard to anticipate what enhancement or shadowing might result so we sought to analyze a typical transit to quantify the effect.

Fortunately, data have recently become available from a long range propagation experiment conducted in the winter that encountered conditions similar to a ship transit across a group of seamounts. It is an analysis of these data we report here.

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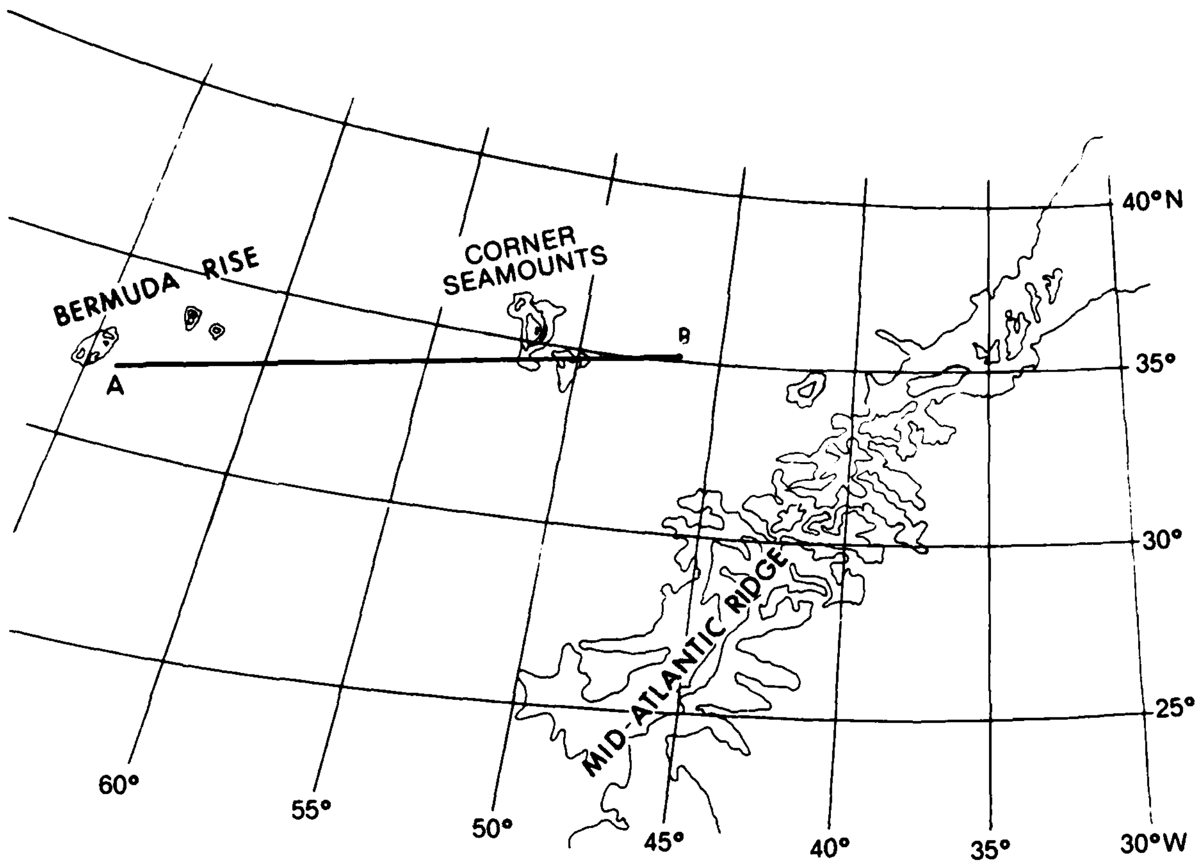

Geographical Location of Measurement Track

Slide 1

The propagation experiment was conducted along a course running 900 nautical miles from Bermuda eastward toward the mid-Atlantic Ridge. At a range of approximately 650 nautical miles, the group of peaks known as the Corner Seamounts was first encountered. Continuing along the track, a series of peaks were crossed in a random fashion for the next 250 nautical miles. As underwater features go, these seamounts are quite steep — with slopes in the neighborhood of 20 to 25 degrees — but seem representative of those in the North Atlantic. From ray theory, we know that rays emanating from a source at 50 degrees will effectively strike the slope at a relative angle of 25 degrees and then be reflected such that they are parallel to the sea surface. It is, thus, apparent that these data should depend on bottom loss that is a function of frequency and grazing angle as well as the slope of the topographic features.

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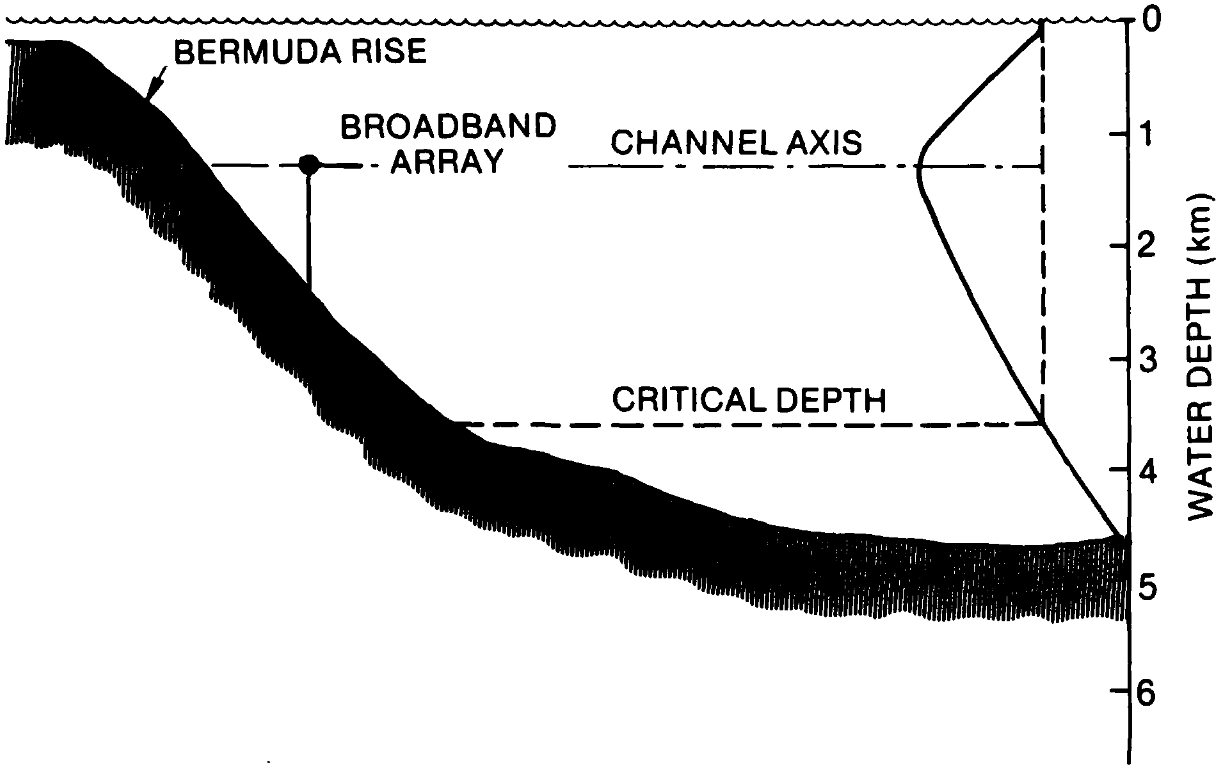

Slide 2

The data were received on a hydrophone of the broadband array that was suspended at the sound channel axis — nominally 1250 meters — and was located near Bermuda. The sound sources were standard SUS charges detonated at four depths (18, 154, 615, and 1230 meters) and dropped uniformly from a ship transiting out along the track.

As the representative sound speed profile on the right shows, there was a depth excess along the track until the seamount group was reached. The critical depth is indicated by the horizontal dashed line.

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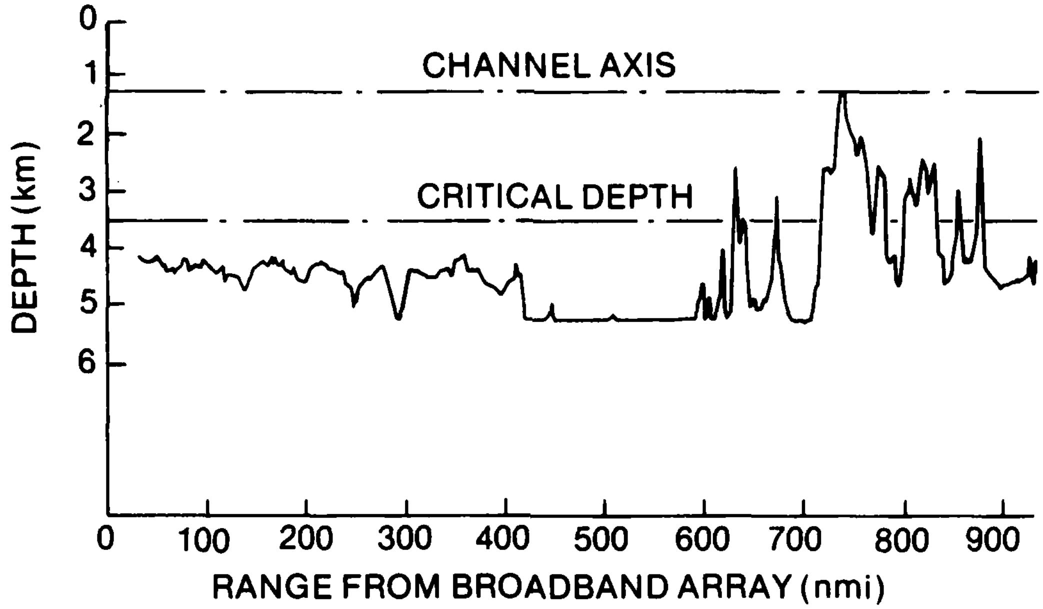

Bottom Topography Along Measurement Track

Slide 3

The bottom topography along the track is shown here with the receiver site located on your left. The sound channel axis is indicated by the upper dashed line and the critical depth or lower boundary of the deep sound channel is indicated by the lower dashed line. Though it would be barely discernible on this scale there exists a well defined surface channel near the seamounts for all source depths down to about 150 meters, which is not present nearer Bermuda.

The first peak to stick up into the sound channel is encountered at a range of 650 nautical miles. This will be designated as *seamount* in the following data slides. The next peak is about 50 nautical miles farther along the track and the highest peak — reaching the sound channel axis — occurs at a range of 750 nautical miles. From there a series of smaller peaks continue out past a range of 900 nautical miles.

Again, the observed peaks are usually not the maximum height of each seamount but represent a typical ship transit across the Corner Seamount Group.

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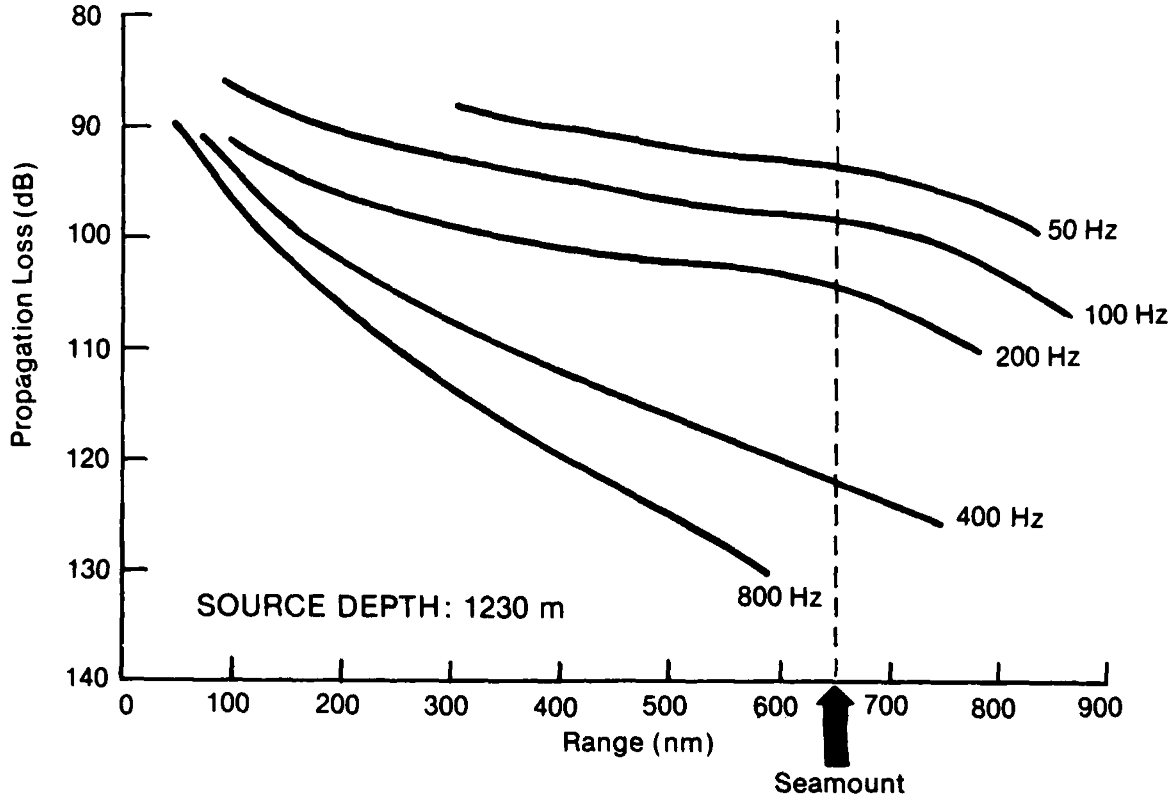

Slide 4

We present our data as propagation loss curves for various frequencies as a function of range for each of the four source depths.

The first results are from the 1230 meter sources at the sound channel axis. With both source and receiver at the axis, the energy should be concentrated in low angle rays.

We do see an increase in energy loss for frequencies of 200 Hz and less, starting at a range of 700 nautical miles. It requires a peak rising to the axis to affect sound in this case. We can't conclude from these data if there is a frequency dependence.

This particular result indicates that sound traveling along the axis — typically from ranges still further on — can be at least partially blocked by these seamounts.

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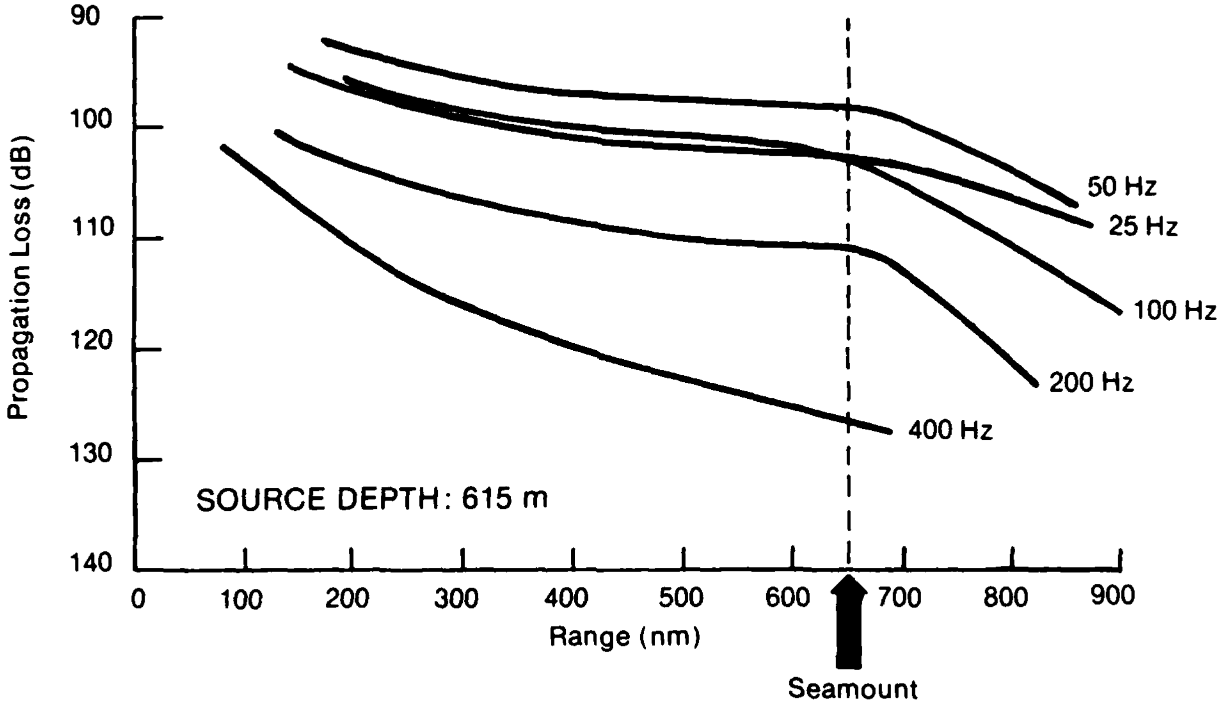

Slide 5

For shots detonated at 615 meters — halfway between the surface and sound channel axis — the change in the rate of loss occurs at the same range — 700 nautical miles. This change in slope is larger and does have a frequency dependence; however, the loss observed in the 100 to 200 Hz range is the largest we found, indicating that we are at least near the optimum conditions for loss for these seamounts.

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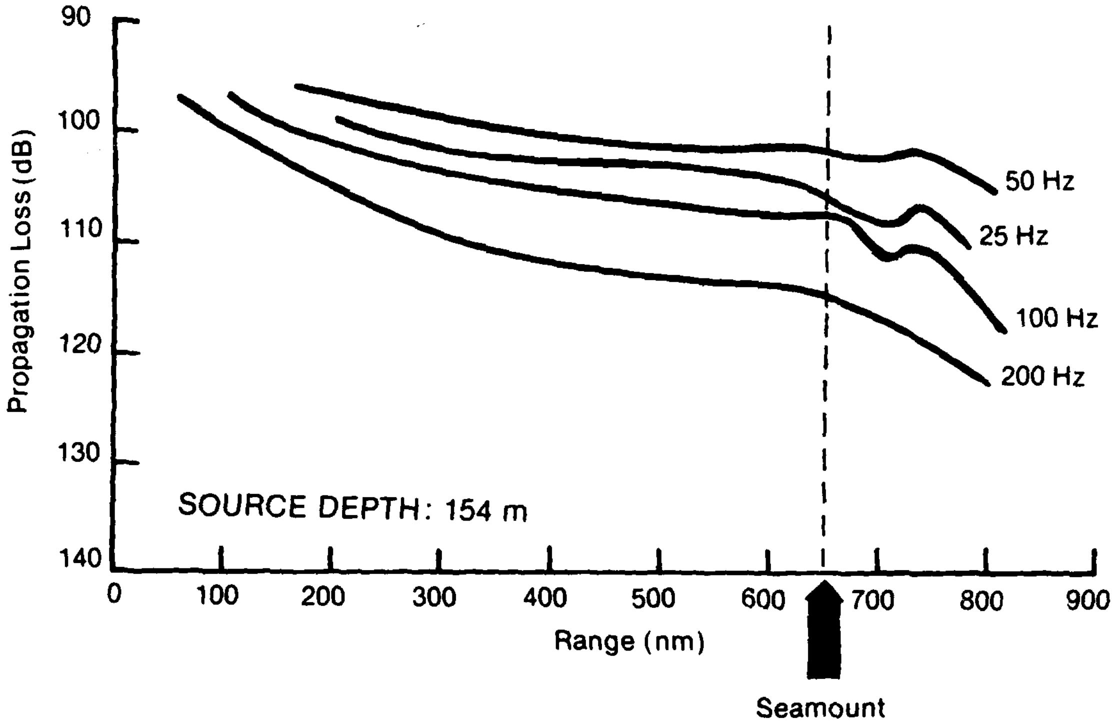

Slide 6

As we detonate sources nearer the surface and very near the bottom of the surface channel at 154 meters, the increased loss starts to show more character indicating varying contributions from each seamount. The effect now starts at a range of 650 nautical miles, those first smaller seamounts now have some influence.

The general trend still shows increased loss, although not as great as for the 615-meter shots. However, for the lower frequencies, there is a distinct peak at the range of the highest seamount. For that particular seamount, we have apparently crossed over from conditions causing loss to those causing enhancement.

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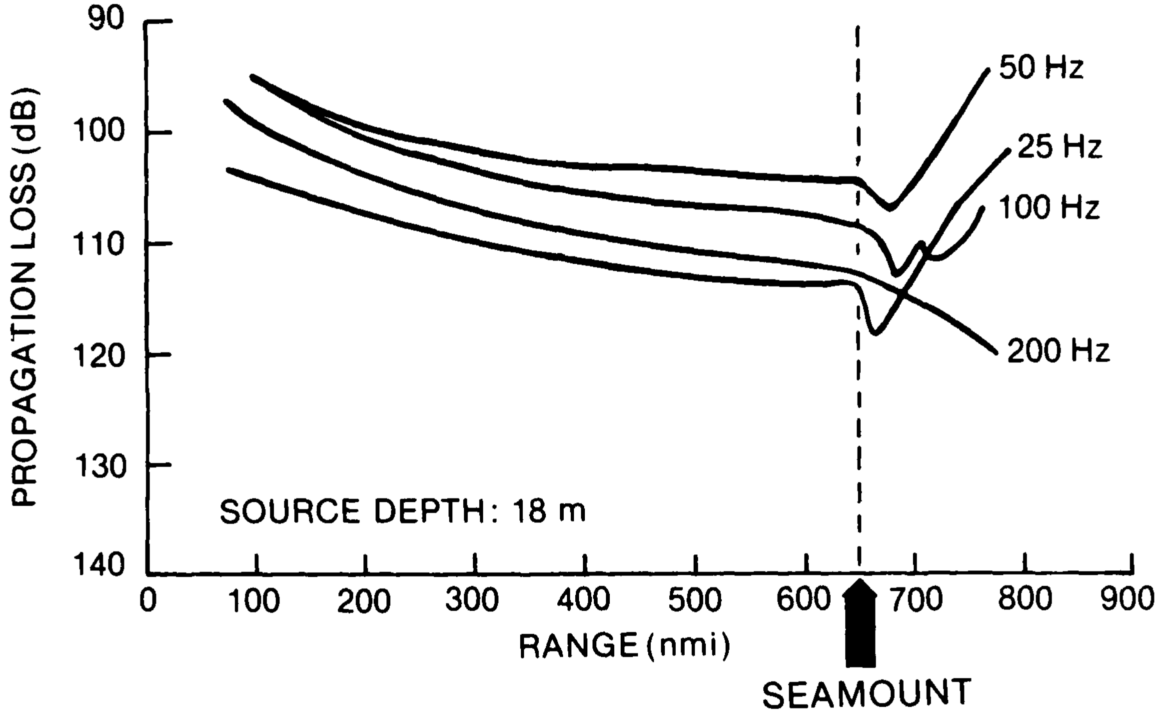

Slide 7

As you might expect, we pass through this transition region even more distinctly with the results for the shallowest (18 meters) sources.

The 200 Hz data still turns down but the 100 Hz data literally oscillates, resulting in almost no average change. Both the 25 and 50 Hz data show a large enhancement. We can see that these seamounts could definitely increase the noise level at the sound channel axis from ships.

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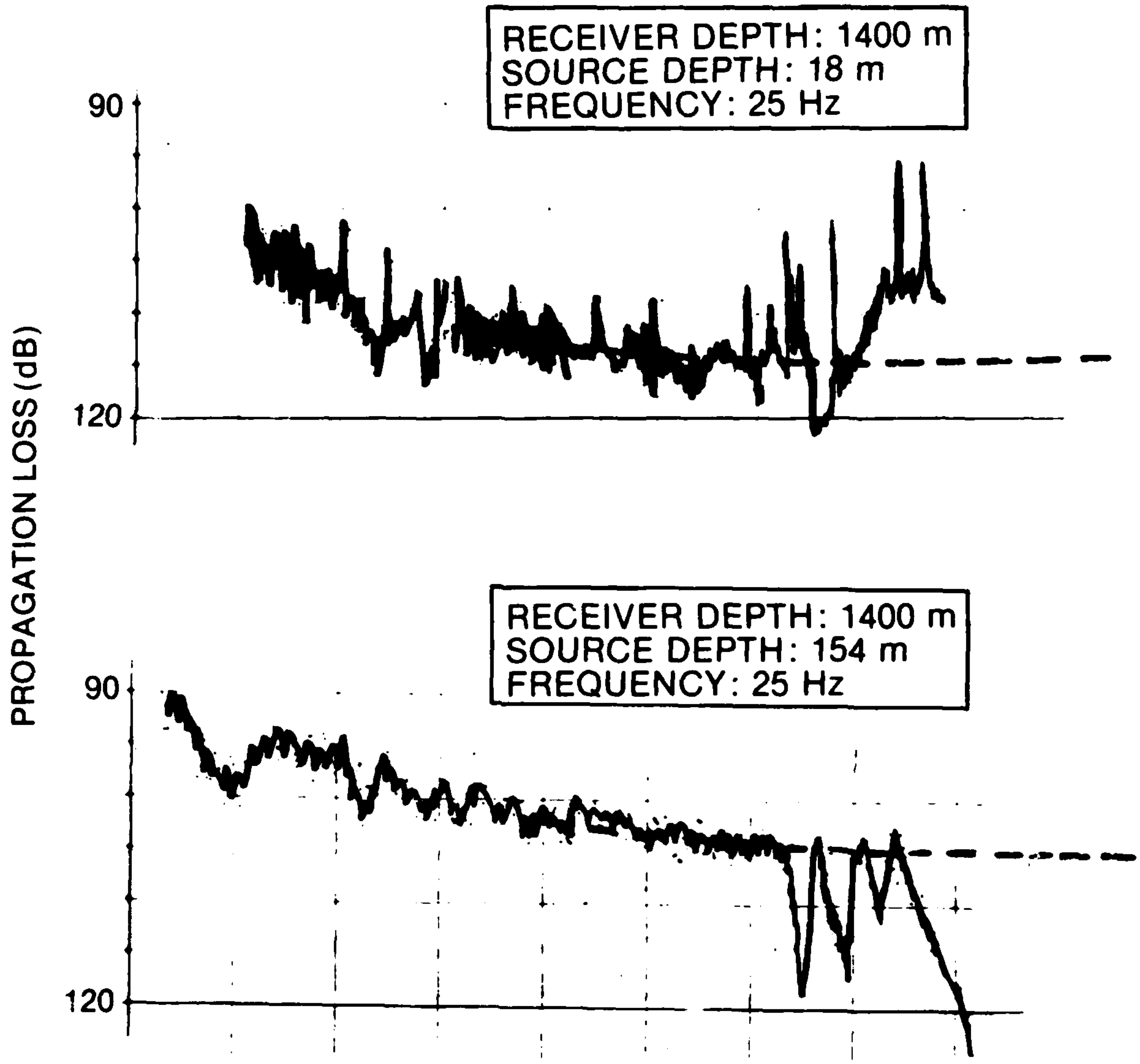

Slide 8

We thought it would make an interesting comparison to show the effect at 25 Hz for the 18-meter shots (top) and for the 154-meter shots (bottom).

The normal propagation loss is indicated by the dashed line in both cases. You can see that by a relatively small change in source depth alone, we obtain significant changes in propagation.

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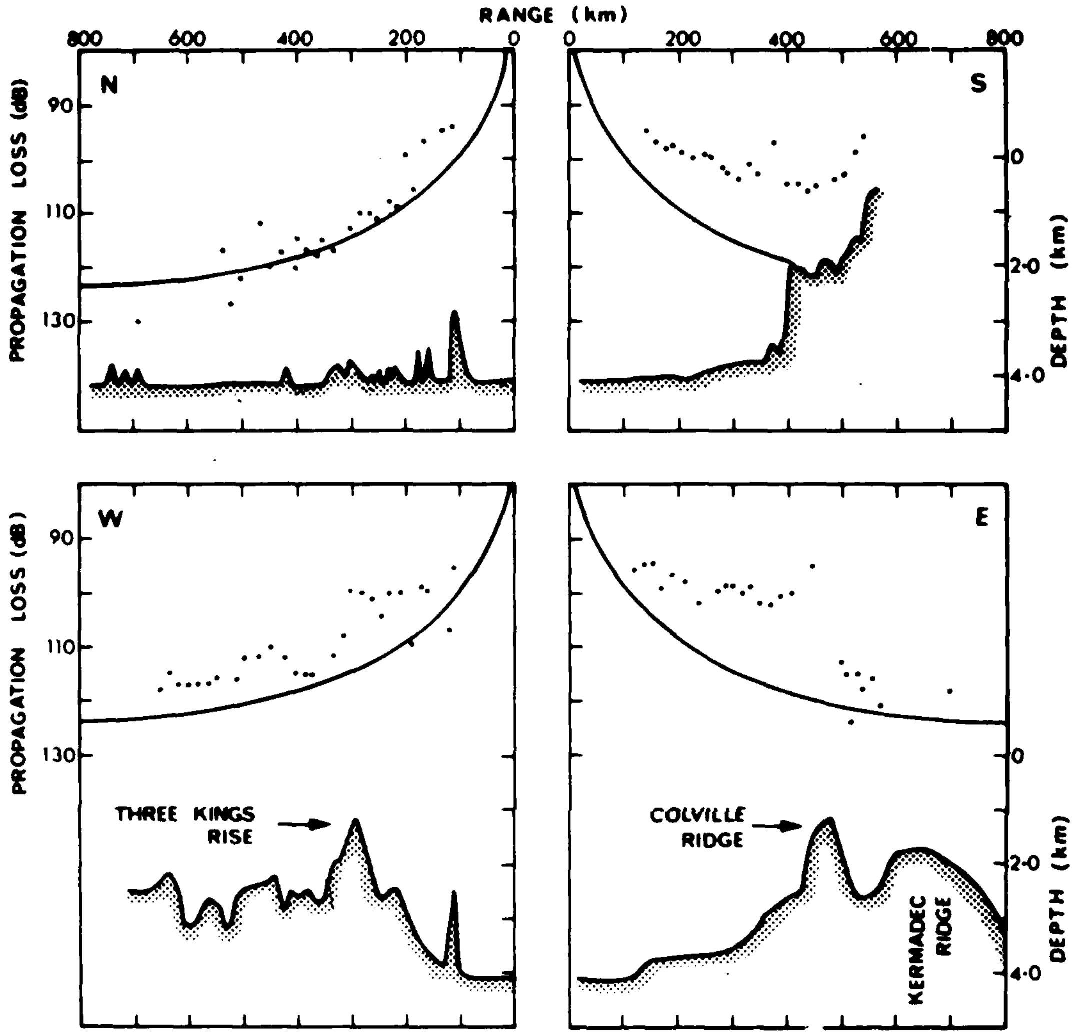

MEASURED AND PREDICTED PROPAGATION LOSSES AT 63 Hz

Slide 9

To see if enhancement from shallow sources crossing seamount groups has been observed elsewhere, we found similar results from the New Zealand experiment, Project SPAN 3. Here we have 4 radial tracks from a receiver located at the sound channel axis (1 km) near the center of the South Fiji Basin. Normal propagation loss is shown by a solid line. The frequency is 63 Hz. In the upper left-hand corner propagation loss is not affected by bathymetry as you would surmise. In the upper-right hand corner, peaks reach the sound channel axis and you can see, as with our data, the effective general enhancement of large topographic features.

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Conclusions

1. **Any Features in the Sound Channel Can Have as an Effect:**
   - **Enhancement**
   - **Shadowing**
   - **Combination Thereof**

2. **Effects are Most Noticeable at:**
   - **Low Frequencies ~ 50 Hz**
   - **Shallow Sources ~ 20 m**
   - **Steep Slopes ~ 20°**

3. **Seamounts Can Increase Ship Generated Noise in the Sound Channel**

Slide 10

In conclusion what do these data show?

First, under realistic conditions in the winter, seamounts can cause enhancement, shadowing, or a combination there-of. These in turn are dependent on the height and slope of the features and bottom loss, which in turn is dependent on frequency and angle of incidence.

Second, enhancement was most notable from low frequencies, shallow sources, and steep slopes. We observed maximum conditions for loss and a transition from loss to enhancement as parameters were changed.

Last, for what represented a typical ship transit, ship noise would indeed be increased in the sound channel by this seamount group, implying a significant increase in heavily trafficked oceans such as the North Atlantic.

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